Chapter 6

Conclusion

This thesis presents the measurements of the $B^0 - \bar{B}^0$ mixing parameter χ_d and the semileptonic branching fractions of B^0 and B^+. The latter measurement was made possible by combining this measurement with the result of an inclusive lepton analysis at CLEO [46]. Assuming the isospin symmetry of neutral to charged B mesons in semileptonic decay, the ratio of charged to neutral B semileptonic branching fractions is equal to the ratio of the charged to neutral B lifetime.

6.1 Summary of $B^0 \bar{B}^0$ mixing parameter χ_d

We measured χ_d through a B^0 enriched sample which has weak dependence on α ($f_{+-}b_+/(f_{+-}b_+ + f_{00}b_0)$) and b_+/b_0. Our result is $\chi_d = 0.189 \pm 0.018 \pm 0.006$. This result is consistent with the χ_d derived from LEP experiments, 0.175 ± 0.011.

We listed the χ_d measurements for comparison in Table 6.1. As can be seen from the table, this result is consistent with other χ_d measurements. In comparison, this result presents the smallest error.

Table 6.1: Comparison with Other Measured χ_d Values.

	χ_d
This result	$0.189 \pm 0.019 \pm 0.006$
ARGUS(94)	$0.16 \pm 0.04 \pm 0.04[80]$
CLEO (93)	$0.149 \pm 0.023 \pm 0.022[49]$
ARGUS(92)	$0.171 \pm 0.048[55]$
CLEO (89)	$0.158^{+0.052}_{-0.059}$ [81]

We can convert our χ_d into x_d through $\chi_d = \frac{x_d^2}{2(1+x_d^2)}$ and the x_d value is found to be $0.774 \pm 0.109 \pm 0.035$. This value is consistent with the averaged result of LEP, 0.734 ± 0.035.[67].

6.1.1 Calculation of V_{td} vs. f_B

Taking the world averaged B^0 lifetime as 1.56 ± 0.04 ps from PDG 98 [76], we can calculate the mass difference of the two neutral B meson CP eigenstates, Δm_{B^0}, through our newly computed x_d. We obtain $\Delta m_{B^0} = 0.496 \pm 0.073$. The Equation 2.41 relates x_d with $|V_{td}|^2$. The V_{td} value converted from x_d has its biggest uncertainty from the B meson decay constant f_B which ranges from 130 MeV to 230 MeV [92]. We obtained the diagram of V_{td} vs. f_B through our x_d in Fig 6.1. The value in that diagram uses the bag parameter $B_d = 1.4 \pm 0.1$ and $\eta_{QCD} = 0.55$ [90]. The top quark mass takes the value $m_{top} = 173.8 \pm 5.2$ GeV [91] and the lifetime of B^0 is $\tau_{B^0} = 1.56 \pm 0.04$ ps [76]. As shown in Fig 6.1, the uncertainty of V_{td} clearly reflects its sensitivity to the uncertainty of f_B. The V_{td} value from the diagram is between 0.007-0.017, consistent with T. Browder and K. Honscheid's estimate, $V_{td} = 0.0092 \pm 0.0003 \pm 0.0009 \pm 0.0024$, where the first error is statistical error, the second error is due to the top quark mass and the third error is due to $B_B^{1/2} f_B$ [92].
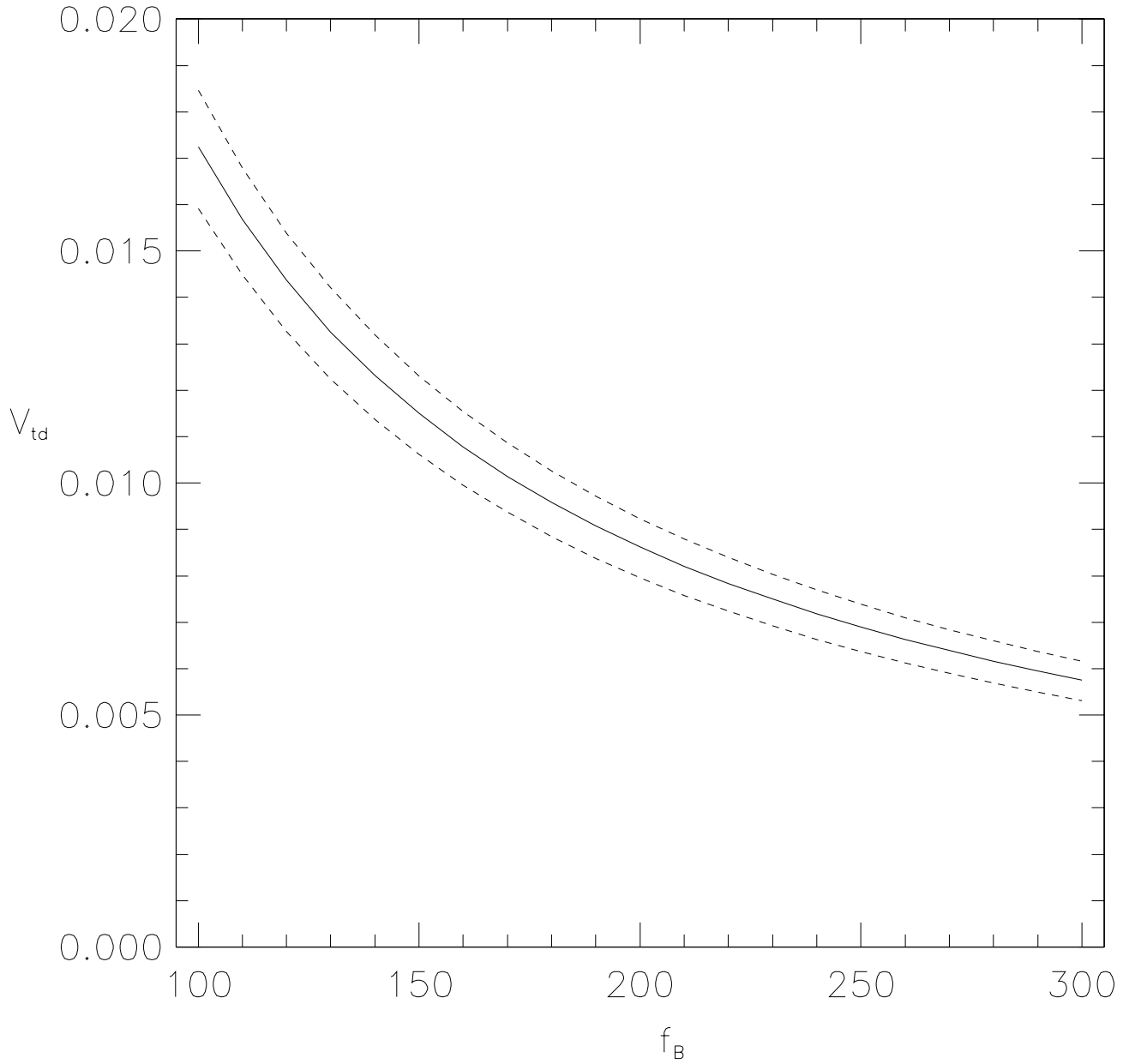
Figure 6.1: V_{td} as a function of f_B. We take top quark mass, $M_{top} = 173.8$ GeV, $\tau_{B^0} = 1.56$ ps and $\eta_{QCD} = 0.55$. The $\pm 1\sigma$ error bands are due to uncertainty on χ_d only.

Table 6.2: Comparison with Other $B \to X\ell\nu$ Value.

	$B^0 \to X\ell^-\bar{\nu}$
Our result	$(10.78 \pm 0.60 \pm 0.69)\%$
CLEO(94)	$(10.9 \pm 0.7 \pm 1.1)\%$[75]
ARGUS(94)	$(9.3 \pm 1.1 \pm 1.5)\%$[80]
	$B^- \to X\ell^-\bar{\nu}$
Our result	$(10.25 \pm 0.57 \pm 0.65)\%$
CLEO(94)	$(10.1 \pm 1.8 \pm 1.5)\%$[75]

6.2 Summary of B Meson Semileptonic Branching Fraction

Our measurement of semileptonic branching fractions gives:

1. $b_0 = (10.78 \pm 0.60 \pm 0.69)\%$.

2. $b_+ = (10.25 \pm 0.57 \pm 0.65)\%$.

3. $\frac{b_+}{b_0} = 0.952^{+0.117+0.060}_{-0.081-0.051}$.

Our value of $Br(B^0 \to X\ell^-\bar{\nu})$ is consistent with the previous CLEO published result, $(10.9\pm0.7\pm1.1)\%$ [75]. Our result for the charged B meson semileptonic branching fraction is consistent with a previous CLEO measurement, $(10.1\pm1.8\pm1.5)\%$ [75], which was published in the same paper as the result of semileptonic branching fraction of neutral B meson. We list different measurements on $B \to X\ell\nu$ for comparison in Table 6.2.

Our measurement of the inclusive semileptonic branching fraction of neutral and charged B mesons adds to the growing body of evidence that the discrepancy between experiment and theoretical prediction, which expects the minimum value should be no less than 12.5%, is real. There is as yet no consensus in the physics community as to the source of discrepancy, and the issue remains a controversial one.

Table 6.3: Table of V_{cb}.

Model	γ_c, ps^{-1}	V_{cb} from $B^0 \to X\ell\nu$	V_{cb} from $B^+ \to X\ell\nu$
ACCMM	40 ± 8	$0.039 \pm 0.002 \pm 0.005$	$0.039 \pm 0.002 \pm 0.006$
ISGW**	42 ± 8	$0.041 \pm 0.001 \pm 0.004$	$0.038 \pm 0.002 \pm 0.004$
Shifman	41.3 ± 4	$0.041 \pm 0.002 \pm 0.002$	$0.039 \pm 0.001 \pm 0.001$
Ball	43.2 ± 4.2	$0.040 \pm 0.002 \pm 0.002$	$0.038 \pm 0.002 \pm 0.002$

We can calculate the CKM matrix element V_{cb} from the value of B semileptonic branching ratio:

$$Br(b \to c\ell\nu) = \tau_B \gamma_c |V_{cb}|^2$$

The γ_c must be calculated with a model. The values of V_{cb} calculated from different models with our measured branching fraction is tabulated in Table 6.3. For the calculation, we take $\tau_{B^0} = 1.56 \pm 0.04$ and $\tau_{B^+} = 1.65 \pm 0.04$ [76] and evaluate V_{cb} from four different model predictions: ACCMM [17], ISGW [18], Shifman $et.al$ [87] and Ball $et.al$ [88]. The first error is the experimental error and the second error comes from the theoretical uncertainty associated with each model. Our V_{cb} result is consistent with the PDG-98 averaged value, $V_{cb} = 0.0395 \pm 0.0017$ [89].

6.3   Summary of τ_+/τ_0

We tabulate the recent measurements on lifetime ratio of neutral to charged B mesons in higher energy experiments, as a comparison with our results in Table 6.4.

Our result of $\frac{b_+}{b_0}$ is also compatible with the previous CLEO result, $(0.93 \pm 0.18 \pm 0.12)$ [75]. We also compare our result with the world average of the direct measurement on $\tau_+/\tau_0 = 1.04 \pm 0.04$ [76], and find no discrepancy.

Table 6.4: τ_+/τ_0 Value Comparison.

	τ_+/τ_0
Our result	$0.950^{+0.117+0.091}_{-0.080-0.068}$
CDF(98)	$1.06 \pm 0.07 \pm 0.02$[82]
SLD(97)	$1.01 \pm 0.07 \pm 0.06$[83]
CDF(96)	$1.01 \pm 0.11 \pm 0.02$[84]
ALEPH(96)	$0.98 \pm 0.08 \pm 0.03$[85]